What is claimed is:

1. A method for forming a conductive damascene structure by filling copper in a plug portion formed on an insulating film, the method comprising:

after etching a low-k material, providing a copper barrier treatment to an etched surface of the low-k material by a surface reforming process performed to carbonize, nitride, bromize, form into boride, reduce, or form into amorphous the etched surface, or a combination thereof; the surface reforming process being performed by making ions accelerated by voltage or neutral particles obtained by diselectrifying the accelerated ions collide against the etched surface in either a same processing chamber as where the low-k material was etched or in a different processing chamber after being transferred thereto in vacuum; and then filling copper in the plug portion having the etched surface provided with the copper barrier treatment.

2. A method for forming a damascene structure according to claim 1, wherein a surface reforming material is deposited on the etched surface before making said accelerated ions or said neutral particles obtained by diselectrifying said accelerated ions collide against the etched surface.

3. A method for forming a damascene structure according to claim 1, wherein the ions are accelerated by a voltage in the range of 1 keV to 50 keV.

4. A method for forming a conductive damascene structure by filling copper in a plug portion formed on an insulating film, the method comprising:

prior to filling copper in the plug portion, forming the plug portion by a film

forming process and an etching process that provide either little or no copper barrier property to side wall portions and plane portions defining inner walls of the plug portion, and then forming at once a copper barrier layer on the side wall portions and the plane portions of the created plug portion by a plasma process utilizing a gas plasma including a component that functions as a barrier against copper.

5. A method for forming a conductive damascene structure by filling copper in a plug portion formed on an insulating film, the method comprising:

prior to filling copper in the plug portion formed to have on its inner wall a two-step trench portion comprising a large cross-section and a small cross-section via a plane portion, forming the plug portion by a film forming process and an etching process that provide either little or no copper barrier property to side wall portions and the plane portions defining the inner walls of the plug portion, and then forming at once a copper barrier layer on the side wall portions and the plane portions of the created plug portion having little or no copper barrier property by a plasma process utilizing a gas plasma including a component that functions as a barrier against copper.

6. A method for forming a conductive damascene structure by filling copper in a plug portion formed on an insulating film, the method comprising:

prior to filling copper in the plug portion, forming the plug portion by a film forming process and an etching process that provide either little or no copper barrier property to side wall portions and plane portions defining inner walls of the plug portion, and then forming at once a copper barrier layer on the side

wall portions and the plane portions of the created plug portion by a plasma process utilizing a gas plasma generated from a mixture including at least a rare gas and one of the following gases; carbon atom-containing gas, nitrogen atom-containing gas, hydrogen atom-containing gas, bromine atom-containing gas, or boron atom-containing gas.

7. A method for forming a conductive damascene structure by filling copper in a plug portion formed on an insulating film, the method comprising:

prior to filling copper in the plug portion formed to have on its inner walls a two-step trench portion comprising a large cross-section and a small cross-section via a plane portion, forming the plug portion by a film forming process and an etching process that provide either little or no copper barrier property to side wall portions and plane portions constituting the inner walls of the plug portion, and then forming at once a copper barrier layer on the side wall portions and the plane portions of the created plug portion by a plasma process utilizing a gas plasma generated from a mixture of rare gas and hydrocarbon gases.

8. A method for forming a damascene structure according to claim 4, wherein the copper barrier layer is formed to reach a depth of 3 nm to 50 nm.

9. A method for forming a damascene structure according to claim 5, wherein the copper barrier layer is formed to reach a depth of 3 nm to 50 nm.

10. A method for forming a damascene structure according to claim 6,

wherein the copper barrier layer is formed to reach a depth of 3 nm to 50 nm.

11. A method for forming a damascene structure according to claim 7, wherein the copper barrier layer is formed to reach a depth of 3 nm to 50 nm.

12. A method for forming a conductive damascene structure by filling copper in a plug portion formed on an insulating film, the method comprising:

prior to filling copper in the plug portion, forming the plug portion by a film forming process and an etching process that provide either little or no copper barrier property to side wall portions and plane portions defining inner walls of the plug portion, and then forming at once a copper barrier layer on the created plug portion by turning gas including at least carbon atom-containing gas, nitrogen atom-containing gas, hydrogen atom-containing gas, bromine atom-containing gas, or boron atom-containing gas into plasma so as to generate ions including said component; accelerating the generated ions by 1 keV to 50 keV; and making the accelerated ions collide against both the side wall portions and the plane portions of the formed plug portion to create the copper barrier layer.

13. A method for forming a damascene structure according to claim 12, wherein the processing of gas into plasma and the colliding of particles against both the side wall portions and the plane portions of the plug portion are performed in atmospheric pressure or greater pressure.

14. A method for forming a damascene structure according to claim 12,

wherein the processing of gas into plasma and the colliding of particles against both the side wall portions and the plane portions of the plug portion are performed in different depressurized conditions.

15. A method for forming a damascene structure according to claim 12, wherein after the etching process is completed, a sample being etched is transferred under depressurized condition to be subjected to the particle collision process.